FIG.1

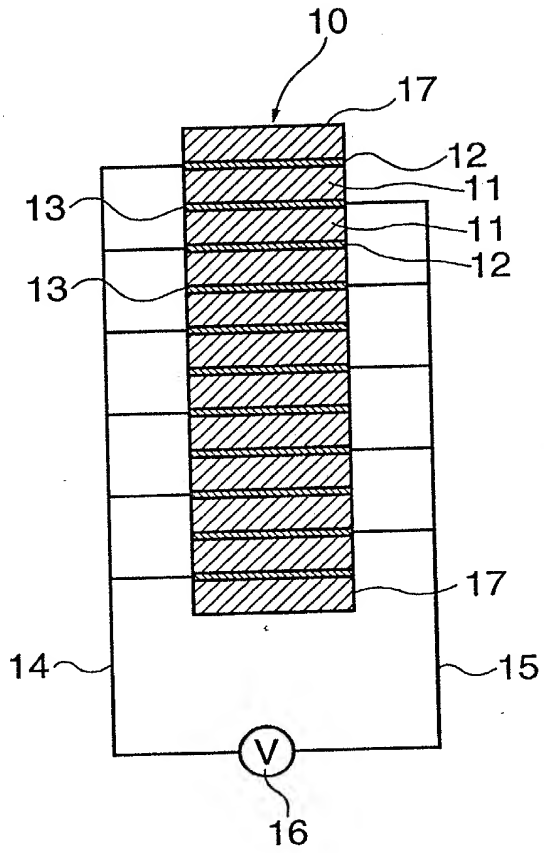


FIG.2

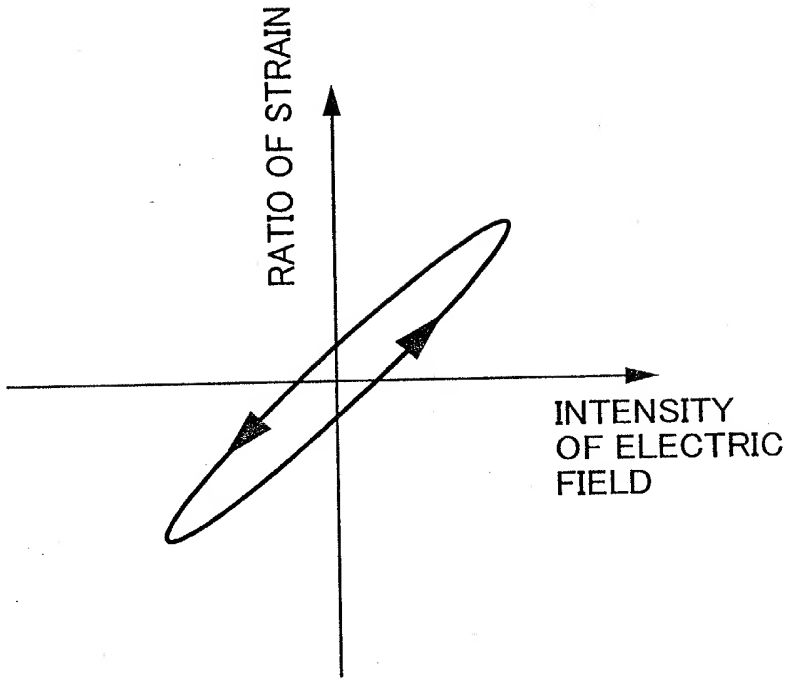


FIG. 3

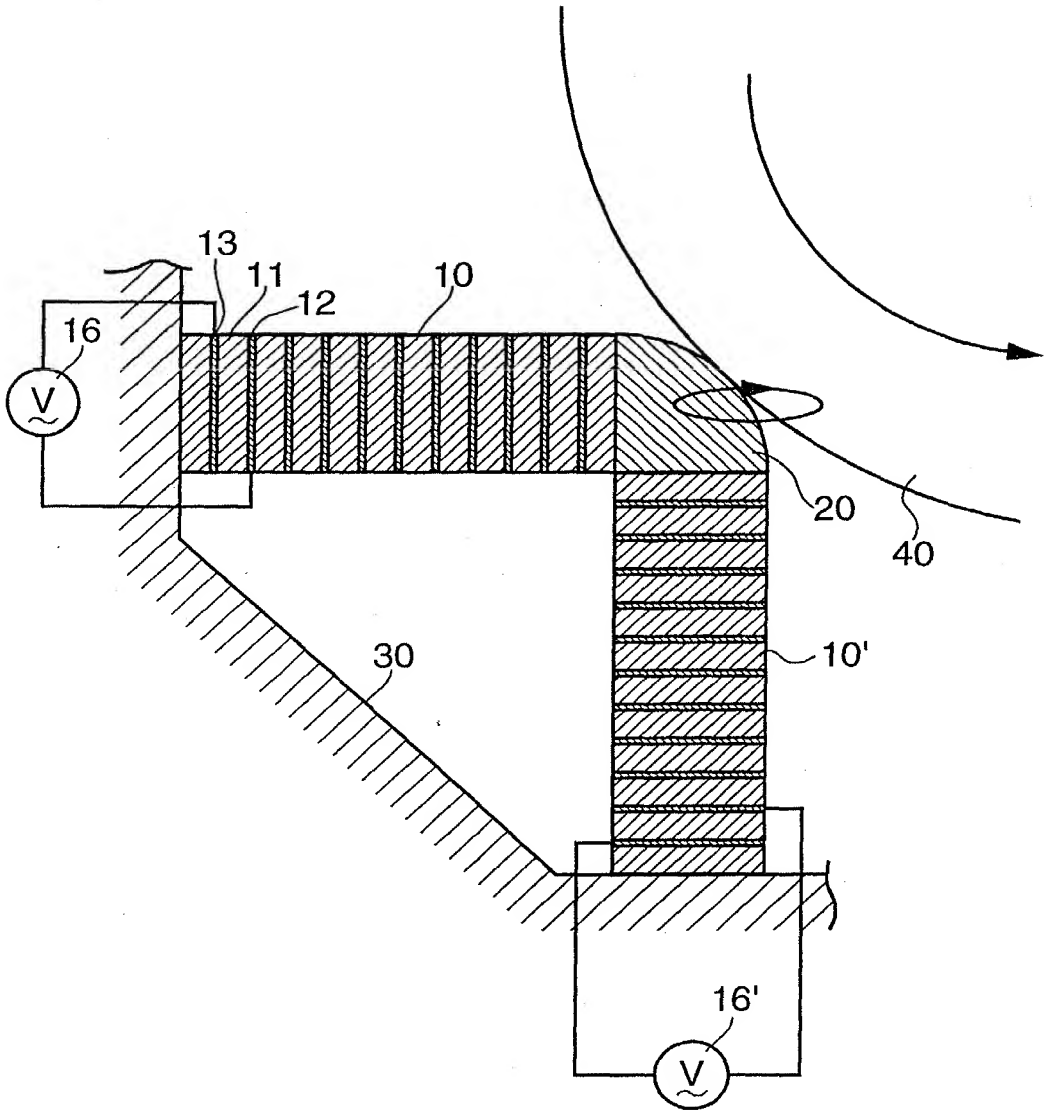


FIG. 4

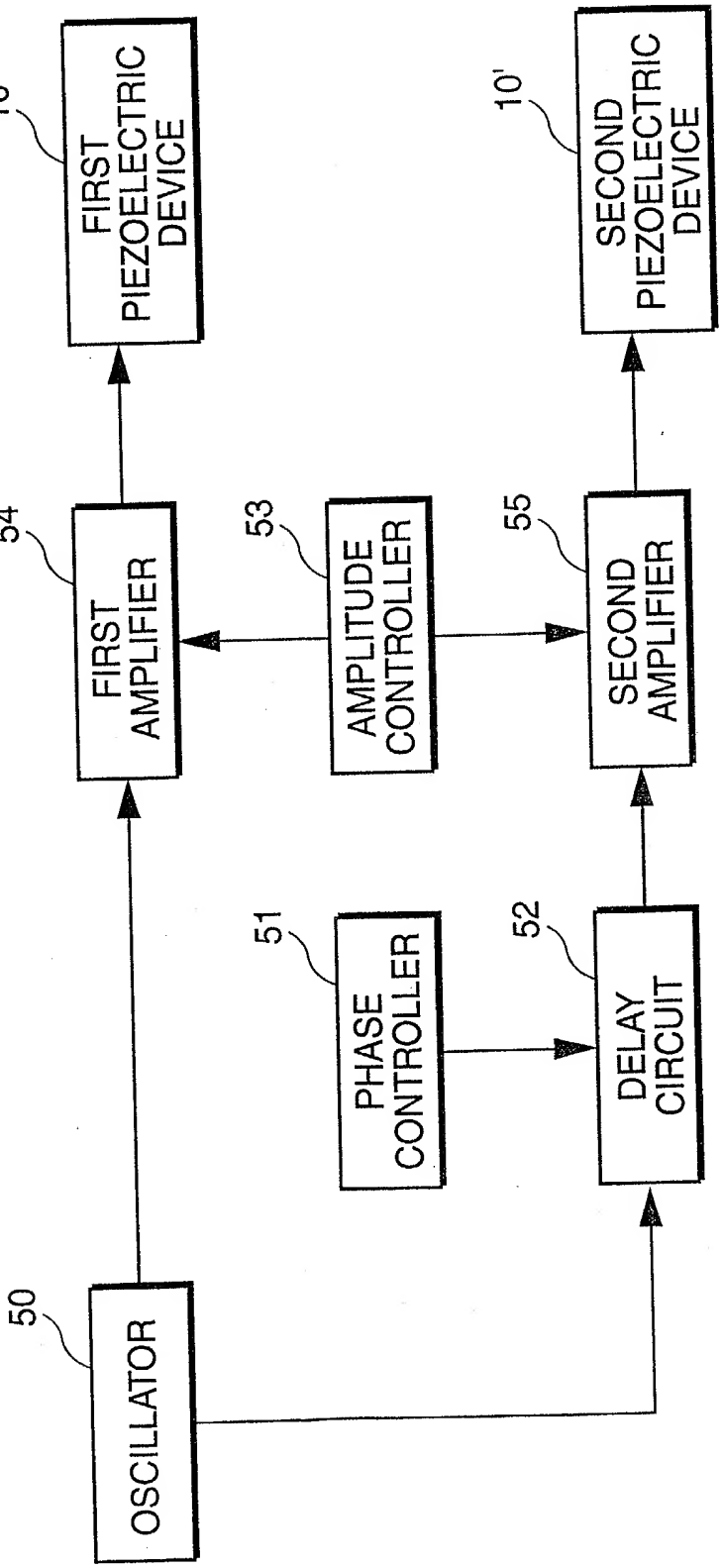

OSCILLATOR
50
PHASE CONTROLLER
51
DELAY CIRCUIT
52
AMPLITUDE CONTROLLER
53
FIRST AMPLIFIER
54
SECOND AMPLIFIER
55
FIRST PIEZOELECTRIC DEVICE
10
SECOND PIEZOELECTRIC DEVICE
10'

FIG. 5

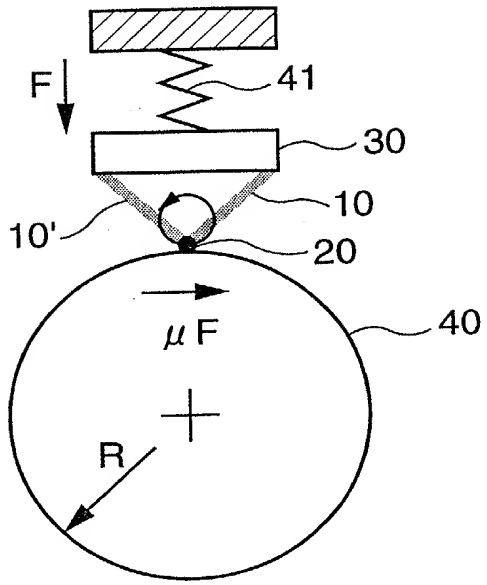
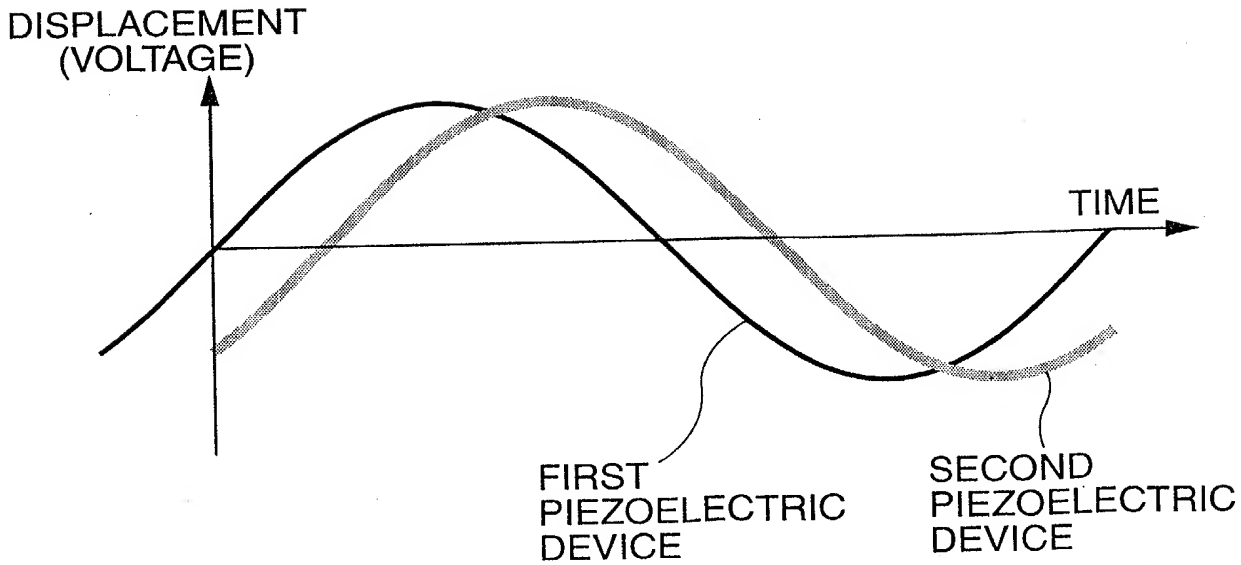


FIG. 6



US 6,552,462 B2

FIG. 7A

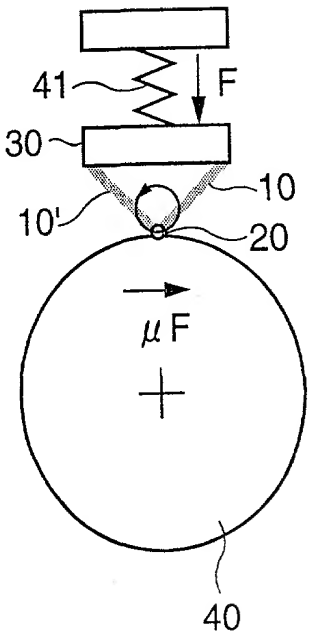


FIG. 7B

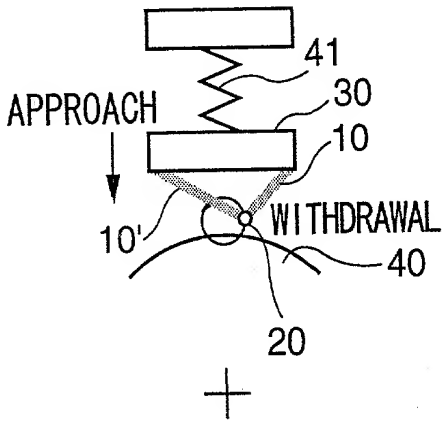


FIG. 7C

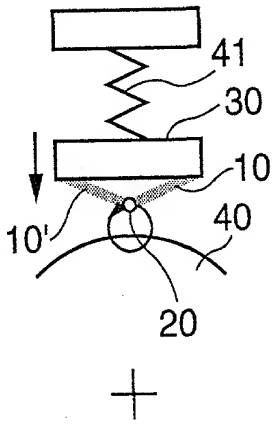


FIG. 7D

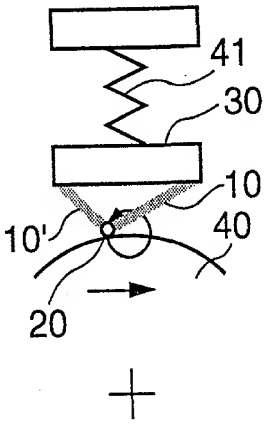


FIG. 7E

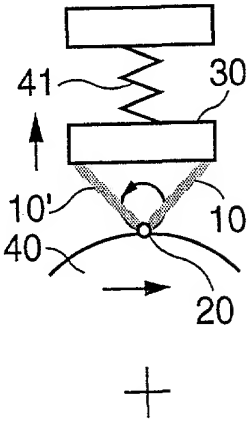
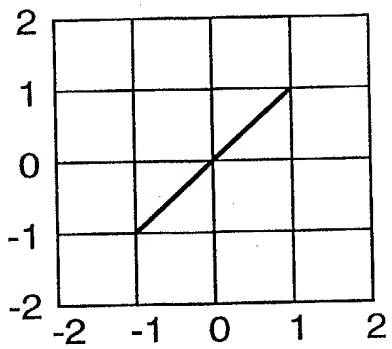
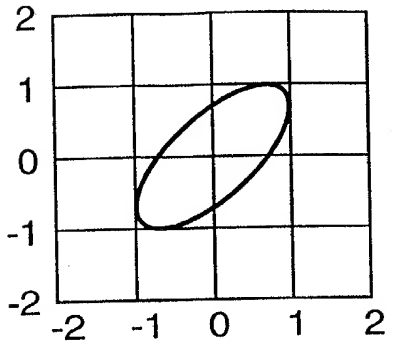


FIG. 8A



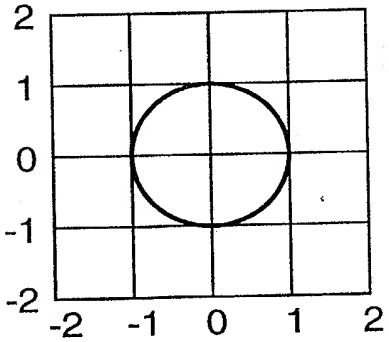
PHASE DIFFERENCE 0°

FIG. 8B



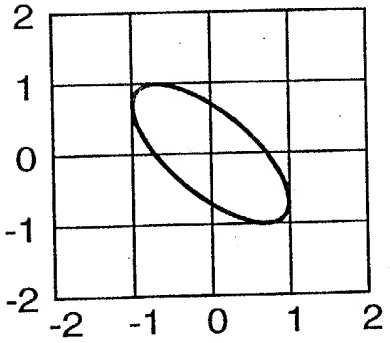
PHASE DIFFERENCE 45°

FIG. 8C



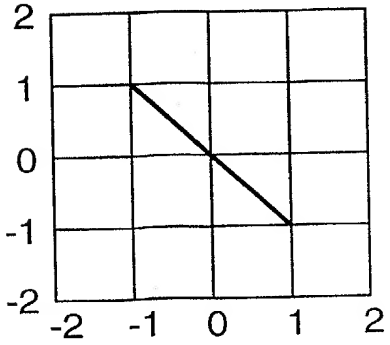
PHASE DIFFERENCE 90°

FIG. 8D



PHASE DIFFERENCE 135°

FIG. 8E



PHASE DIFFERENCE 180°

US 5,539,832

FIG. 9A

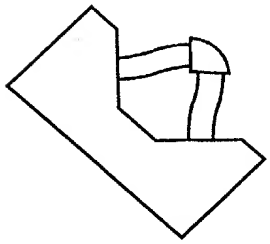


FIG. 9B

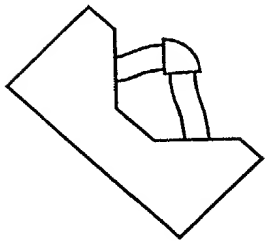


FIG. 9C

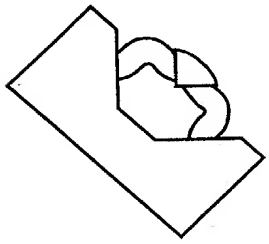


FIG. 9D

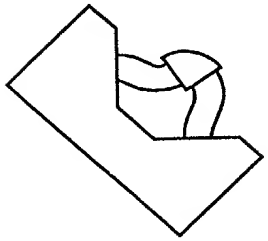


FIG. 10A

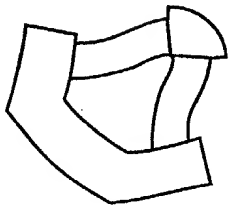


FIG. 10B

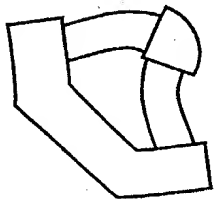


FIG. 10C

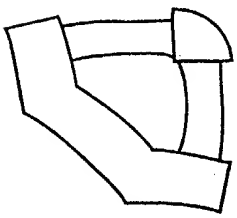


FIG. 10D

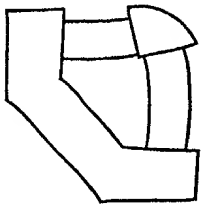


FIG. 11

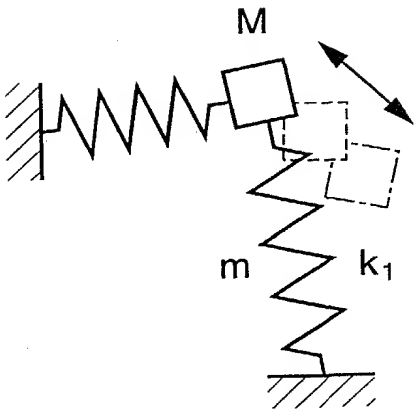


FIG. 12

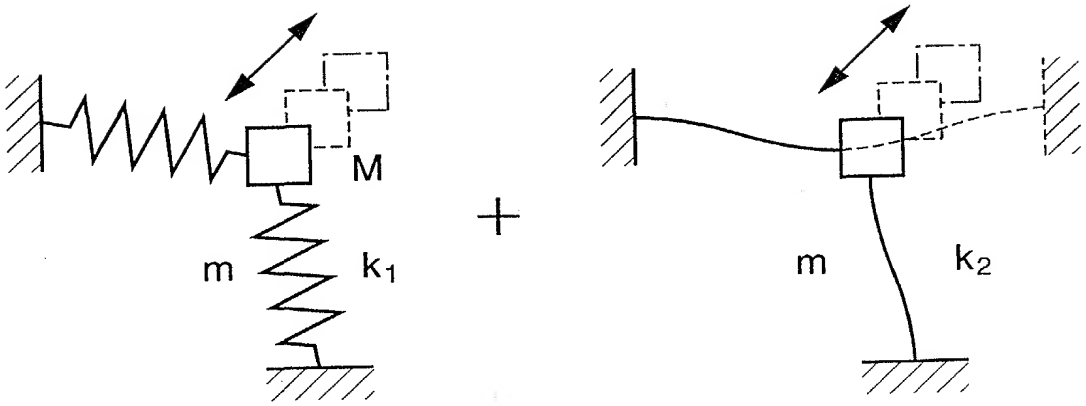
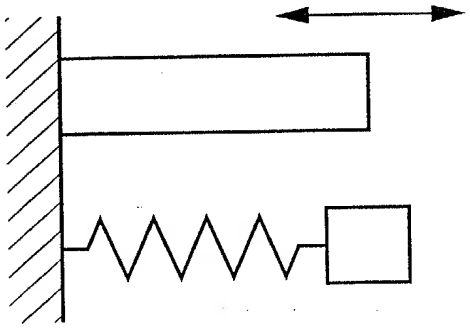


FIG. 13A

AN END CONSTRAINED



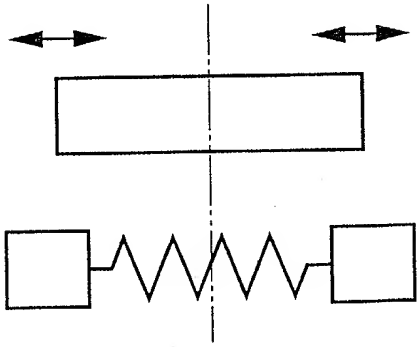
SPRING CONSTANT : k=SE/L
MASS : m
ANGULAR FREQUENCY : ω^2=k/ (m/3)

S : CROSS-SECTIONAL AREA
L : LENGTH

NODE

FIG. 13B

BOTH ENDS FREE



k' =SE/ (L/2)
=2k
m' =m/2
ω'^2 =k'/(m'/3)
=$(2\omega)^2$

NODE

FIG. 14A

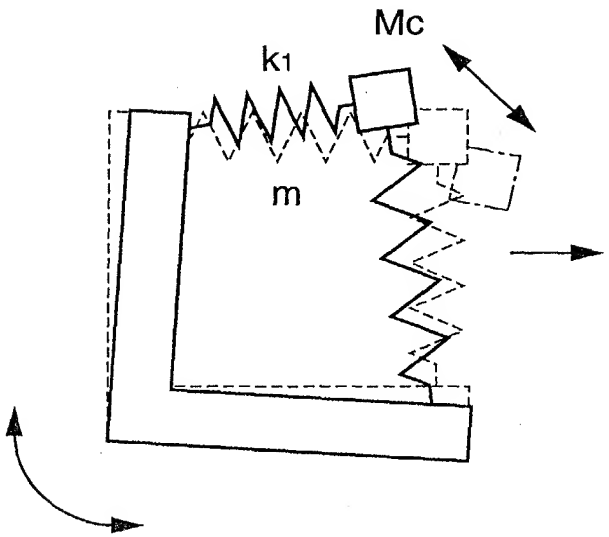


FIG. 14B

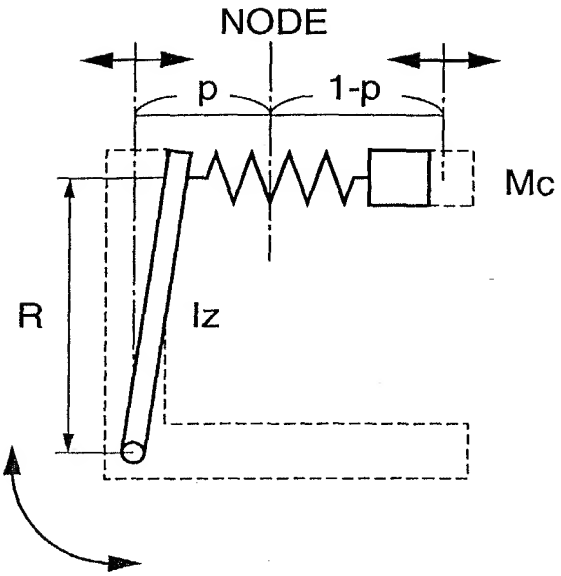


FIG. 15A

EXPANSIVE MOTION

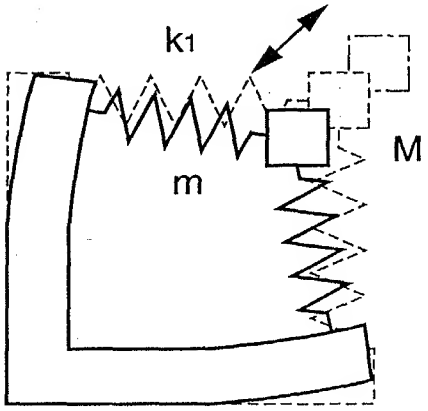


FIG. 15B

EXPANSIVE MOTION

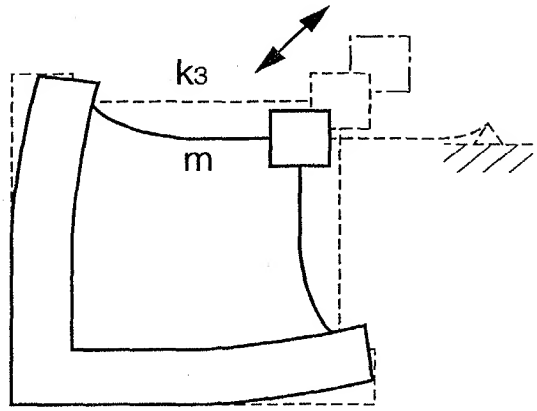


FIG. 15C

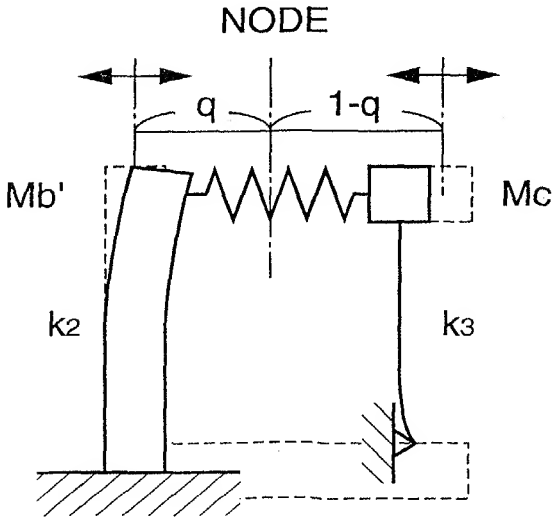


FIG.16

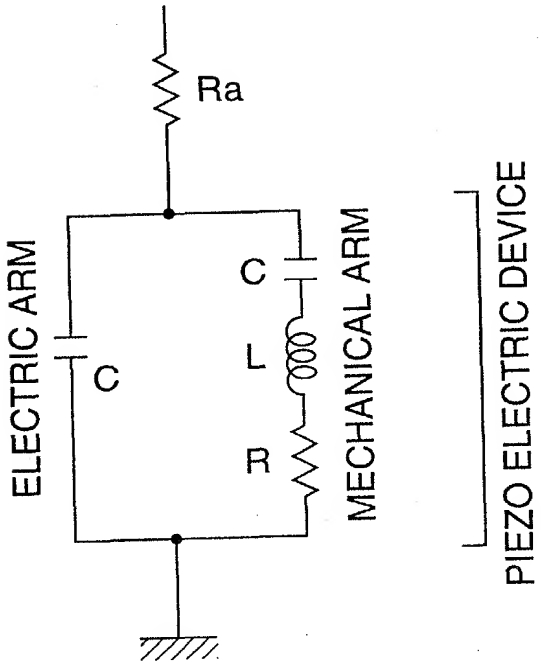
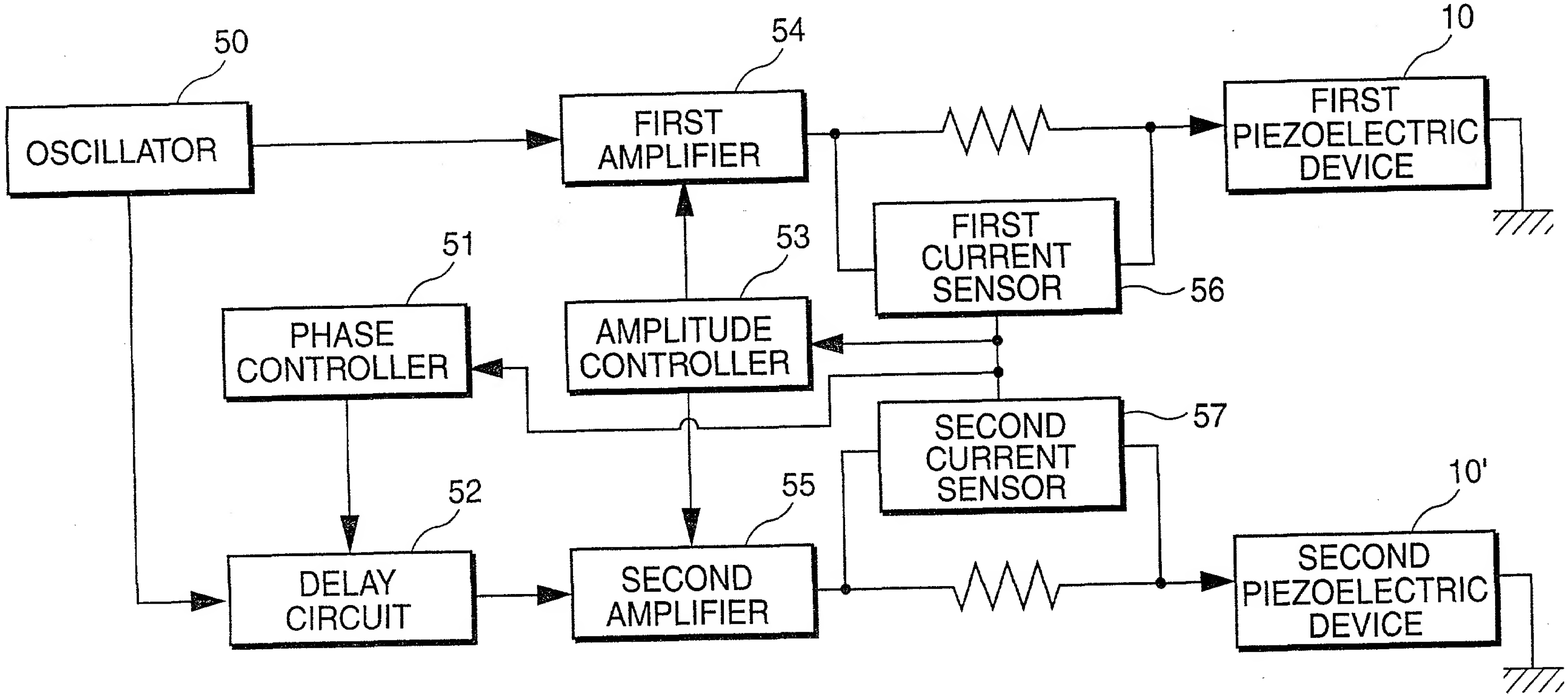


FIG. 17



50
OSCILLATOR
54
FIRST AMPLIFIER
10
FIRST PIEZOELECTRIC DEVICE
51
PHASE CONTROLLER
53
AMPLITUDE CONTROLLER
FIRST CURRENT SENSOR
56
SECOND CURRENT SENSOR
57
52
DELAY CIRCUIT
55
SECOND AMPLIFIER
10'
SECOND PIEZOELECTRIC DEVICE

FIG. 18A

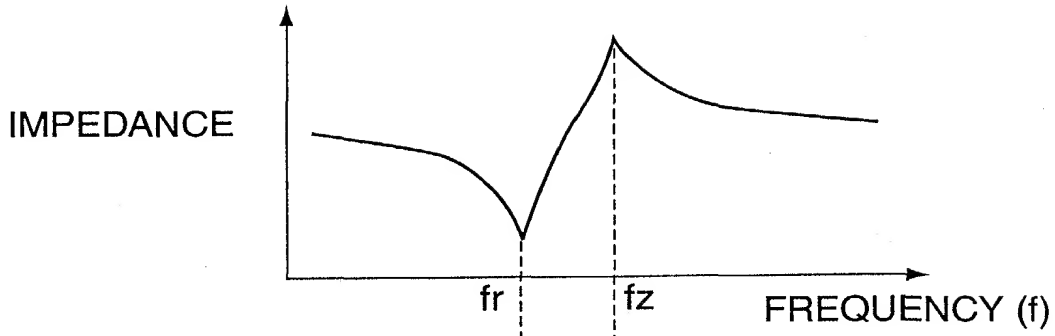


FIG. 18B

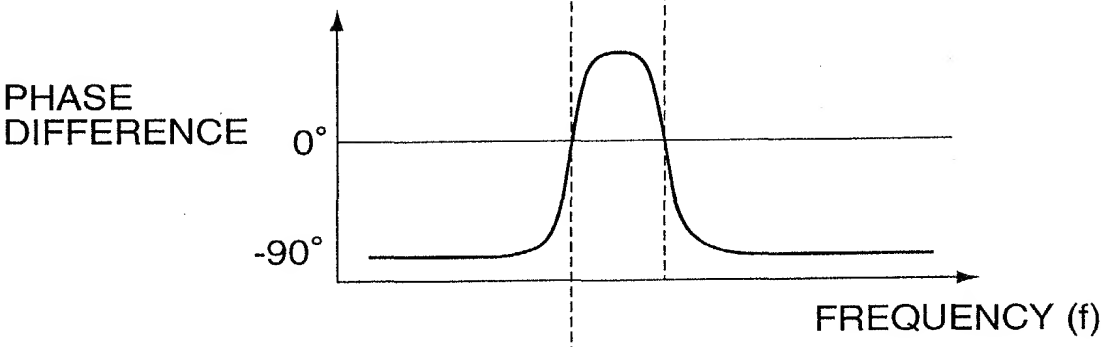


FIG. 18C

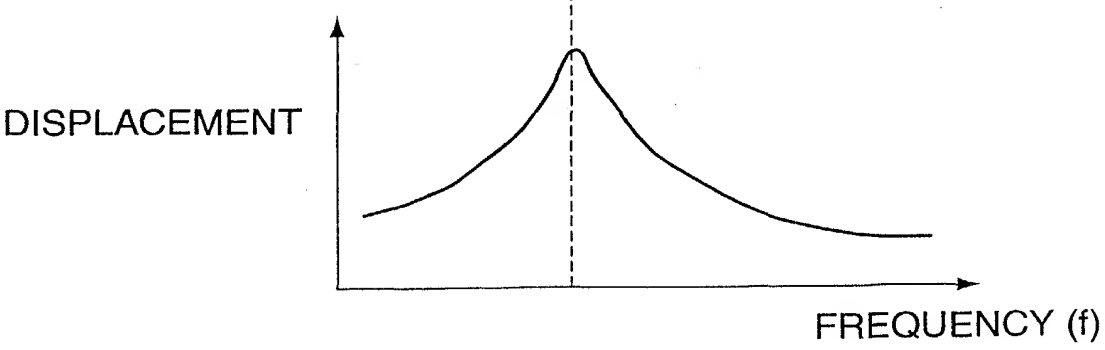


FIG. 19A

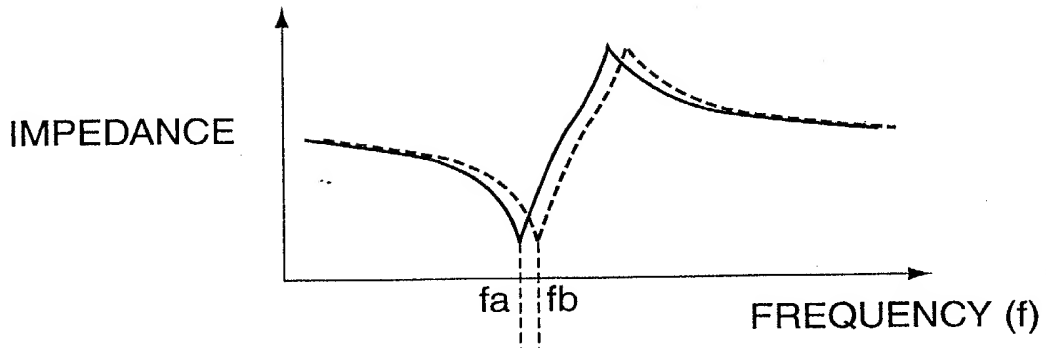


FIG. 19B

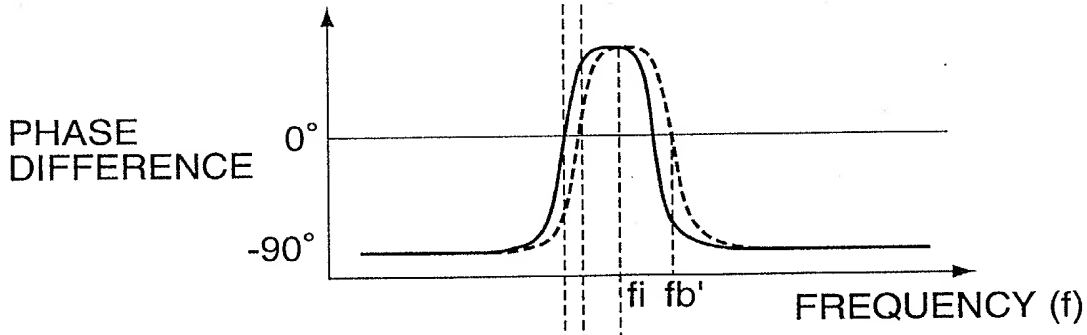


FIG. 19C

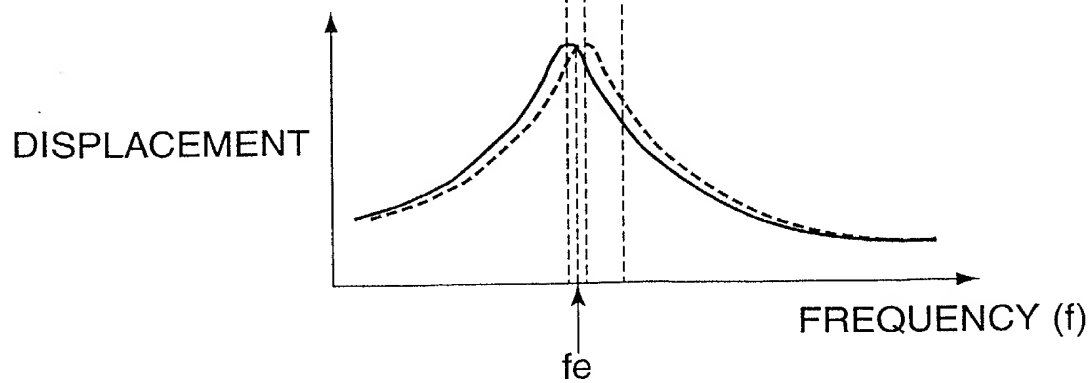


FIG. 20A

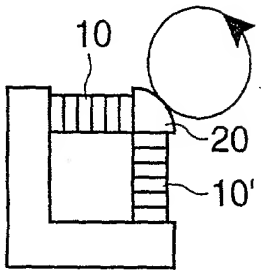


FIG. 21A

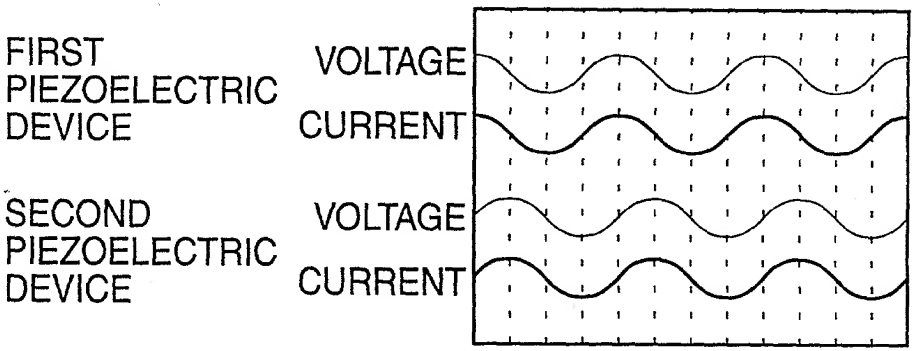


FIG. 20B

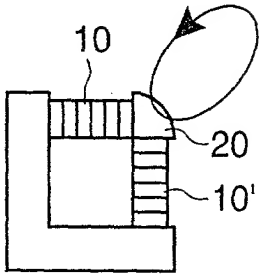


FIG. 21B

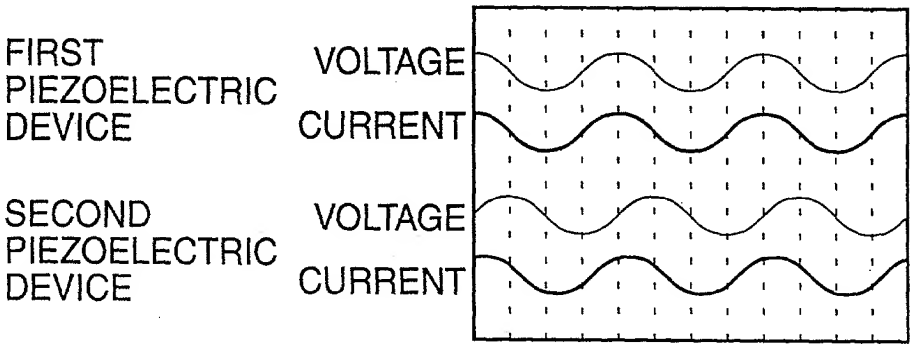


FIG. 20C

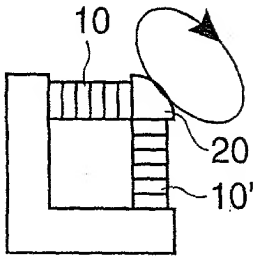


FIG. 21C

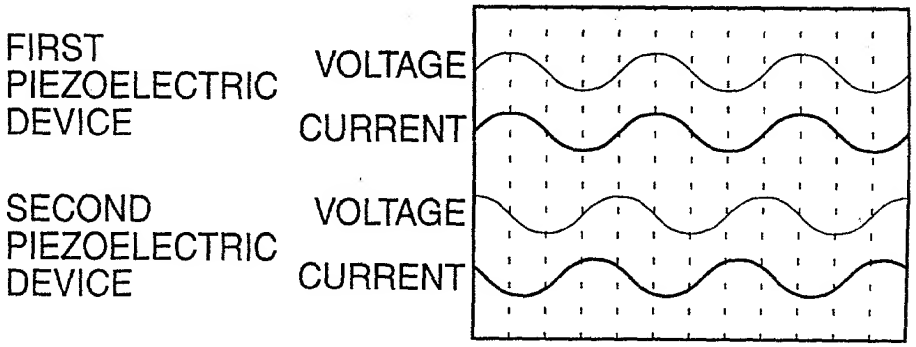
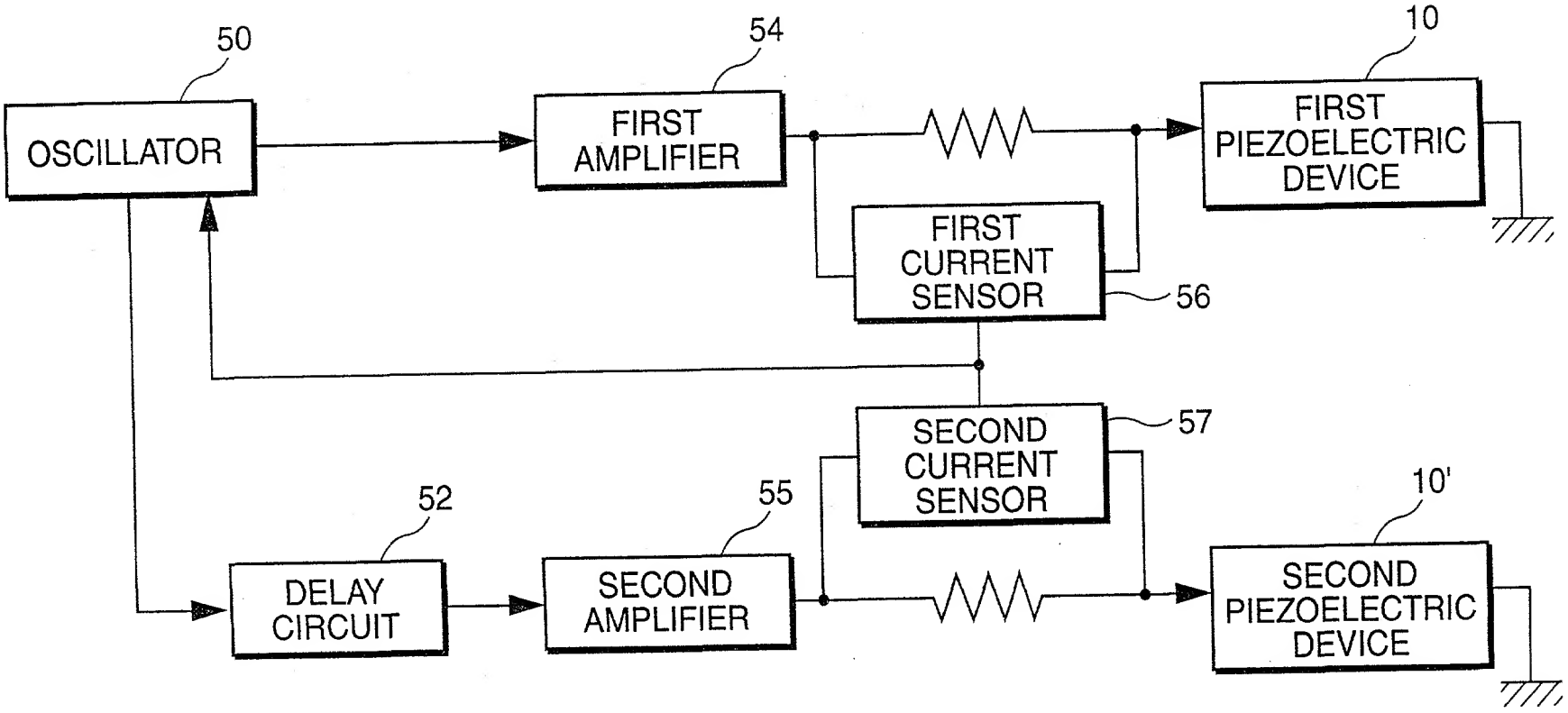


FIG. 22


50
OSCILLATOR
54
FIRST AMPLIFIER
10
FIRST PIEZOELECTRIC DEVICE
FIRST CURRENT SENSOR
56
SECOND CURRENT SENSOR
57
52
DELAY CIRCUIT
55
SECOND AMPLIFIER
10'
SECOND PIEZOELECTRIC DEVICE

006090 "2975660

FIG. 23

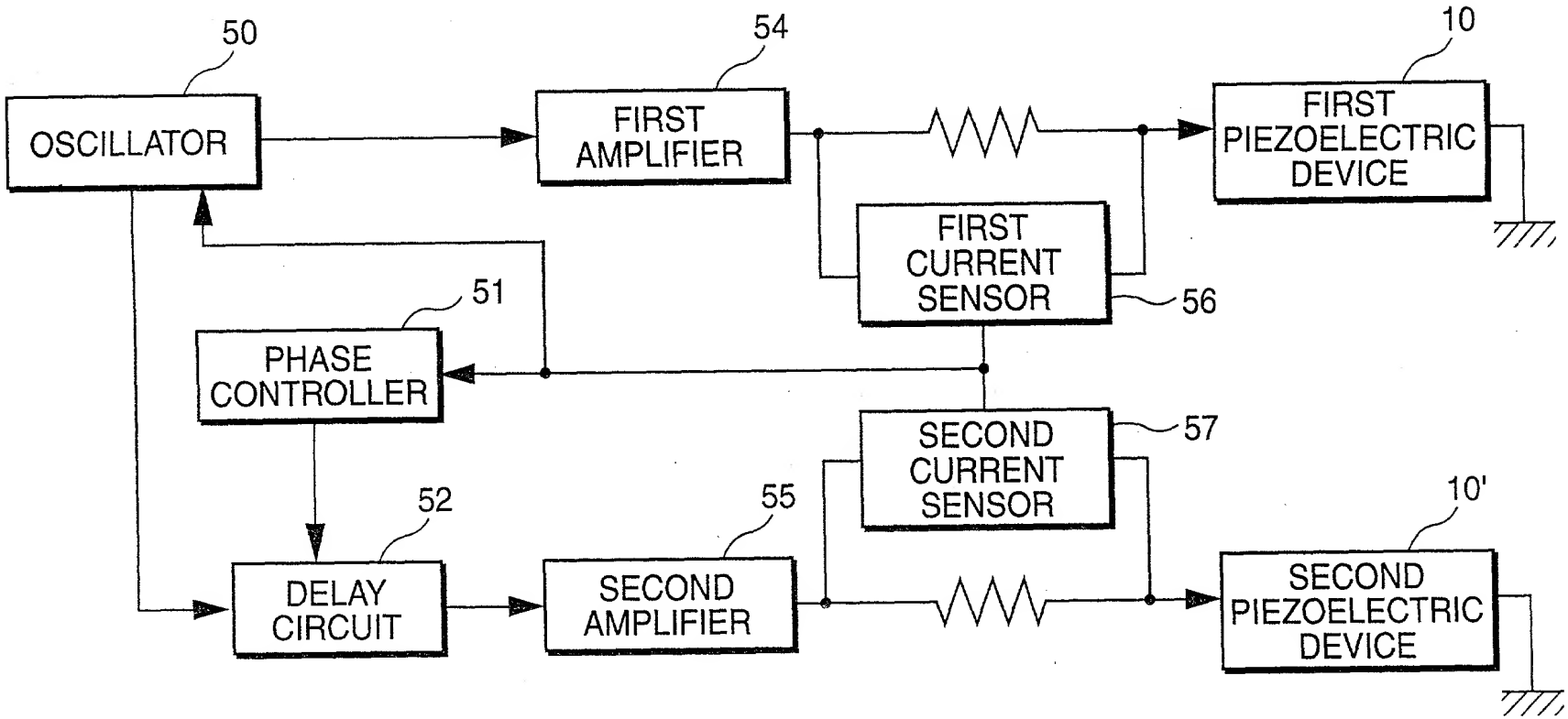


FIG. 24